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Assessment of water quality contaminated with arsenic using diatoms and Ostracodtoxkit F test

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Abstract. The release of such contaminants as metals into aquatic environment and its accumulation in sediment is a great concern due to the potential effect to the whole ecosystem. Water biocoenosis can change completely with the introduction metals into the water course. The aim of the study was to compare the water quality of three small streams contaminated with arsenic on the basis of multimetric diatom index IO and microbiotest designed to evaluate sediment toxicity (The Ostracodtoxkit F). The quality of three small streams located within Złoty Stok community in Lower Silesia (SW, Poland) has never been assessed with the biological methods before. What is more, the impact of arsenic on water biocoenosis has been rarely studied worldwide. Such studies have not been conducted before in Poland. The findings showed that each of used method classifies similarly three studied streams. The obtained results confirmed that the biological methods are the most reliable in the assessment of water quality.

1 Introduction

Metals can enter the water naturally and as a result of anthropogenic activities. Their presence could place the health of the environment at risk. Biomonitoring methods reflect processes in living organisms and measure impact of metals and other pollutants on their health. In terms of reliability and cost-effectiveness, bioindiactors are very appropriate biomonitors for short- and long-term environmental monitoring of metals [1, 2]. Including the microorganisms, the assemblage of macrophytes, microalgae, macroinvertebrates and fish has been used to monitor water quality in aquatic ecosystems for different purposes [3]. Diatoms have been recognised as good indicators of land use and water quality. They are very improtant contributors of freshwater ecosytem and as excellent bioindicators respond very fast to environmantal changes [4]. In Poland, in accordance with the regulation of the Minister of the Environment (OJ No 162, pos. 1008 from 2008) the multimetric IO index is recommended to assess water quality [5, 6]. Simultanously, various microbiotests have developed greatly to asses water and sediments quality. The application of microbiotests allows to assess the toxicity of ecosystem very fast. In the study region the primary source of pollution with arsenic is an ancient gold mine and dumps left after gold processing with

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chlorination. The additional source of pollution are lechaetes coming from the former industry producing arsenic trioxide [7]. What is more, the area is threatened with domestic and agricultural pollutants. The main aim of the study was to assess the impact of arsenic contamination on living organisms and to evaluate application of microbiotest and multimetric diatom index in sediment toxicity and water quality testing.

2 Materials and methods

2.1 Material

All study sites were located in the Lower Silesia in Złoty Stok community (SW, Poland). Three study sites (small streams) have been chosen for samples collection (Site 1 Czysty Potok, Site 2 Mąkolno and Site 3 Trujący Potok). Samples were assembled twice in the year 2017 (June and August). Diatoms were collected into containers and stored in 4% formalin solution. The samples were digested with sulfuric and chromic acids then permanent slide mounts were prepared using the high resolution mountant Naphrax®. Diatoms are characterized by a cell wall saturated with silica. This "shell" is very durable and after preparation it is very characteristic and visible during microscopic observation. Diatom frustules were observed and identified at the lowest taxonomic level possible.

Sediment from each of the sites was collected and transported to laboratory. Sediment was collected from the top 2–3 cm of the stream bed with plastic spatula. The samples of sediment were dried for 6 days at 30°C.

2.2 Methods

2.2.1. Diatom index IO

The IO index is based on the arithmetic mean from three parameters such as the trophic index (TI) [8], saprobic index (SI) [9] and abundance rate of the reference species from the list created by Schaumburg et al. [10]. The IO index was calculated applying an appropriate formula suitable for type of rivers/streams corresponding to the hydromorphology of the 3 types of streams studied. The range of the diatom index and the ecological status that was indicated by the index were used together with a water quality class for the IO index according to the regulation of the Minister of the Environment (OJ No 258, pos. 1549 from 2011).

2.2.2. Ostracodtoxkit F

Ostracod exposure tests were conducted in the form of 6 replicates per site sample and 1 control per sample by using reference sediment according to the standard operating procedures of the test kit [11]. Ostracod neonates of the benthic ostracod crustacean *Heterocypris incongruens* were exposed to test sediments (6 days in darkness at 25°C ± 2°C). At the end of the test period, all surviving ostracods were counted and measured with micrometre cover slip. Growth inhibition of surviving ostracods exposed 6 days to studied sediments was determined in relation to (non-toxic) reference sediment. The percentage mortality was also determined.

2.2.3. Arsenic concentration

Table 1 presents the results for arsenic in water. ICP- OES (Inductively Coupled Plasma Optical Emission Spectrometry) was done commercially in the Environmental Laboratory Lab S.C. in Wrocław.

Table 1. Arsenic concentration in the collected samples of water with p H values.

No.	Site	Arsenic [mg/l]	pH
1.	Czysty Potok (1)	< 0.01	6.64
2.	Mąkolnica (2)	0.005	7.62
3.	Trujący Potok (3)	0.023	7.72

The limit values for arsenic content in surface water is 0.01 mg/l. Samples collected in Trujący Potok (site 3) exceed the limits only. The metal content in sites 1 and 2 do not exceed the norm.

3 Results and discussion

3.1 Multimetric diatom index IO

A total of 79 diatoms were identified at 3 studied sites. The table 2 presents the results of calculation of diatom index and water quality classification for all sites.

Table 2. The values of multimetric diatom index and water quality class for all studied sites.

Site	IO	Water quality class	Ecological status
Czysty Potok (1)	0.72	I	Very Good
Mąkolnica (2)	0.6	II	Good
Trujący Potok (3)	0.36	III	Moderate

The biological assessment of the water quality conducted on the basis of multimetric diatom index IO showed different ecological status at three studied sites. The values for Czysty Potok (site 1) were the highest (0.72) and for Trujący Potok (site 3) the lowest (0.36). Mąkolnica (site 2) reached 0,6. All streams were in different quality class (site 1 –very good, site 2 – good, site 3 moderate). The chemical analysis of arsenic content indicated similar results between the values of metal concentrations and water quality class (site 1 – very good, arsenic concentration does not exceed the norm; site 2 – good, arsenic concentration does not exceed the norm, site 3- moderate, arsenic concentration exceeded the norm). The obtained results confirm the usefulness of the biological assessment in the evaluation of the ecological status of water ecosystems.

3.2 Ostracodtoxkit F

In order to assess the chronic toxicity of the sediment at all sites, the length of the organisms was measured and the percentage of mortality and percentage of inhibition growth were determined and on the first and sixth day of the experiment. The results are shown Table 3.

Table 3. The results of Ostracodtoxkit F.

Site	The average length of the body day 0 [mm]	The average length of the body day 6 [mm]	Mortality [%]	Growth inhibition [%]
Control	184	512	-	-
Czysty Potok (1)	184	502	13	6
Mąkolnica (2)	184	480	50	12
Trujacy Potok (3)	184	325	87	58

Site 3 sediment exposure indicated 87% ostracod mortality and 58% inhibition growth, sediment collected at site 2 resulted in 50% mortality and 12% inhibition growth. Growth of ostracods exposed to sediment from site 1 was inhibited by 6% and 13% mortality rate. These findings coincide with the results obtained for multimeric diatom index (IO), but in all cases the mortality and growth inhibition of ostracods was recorded. The mobility of sediment is slow, thus contaminated sediments change very slowly over long time period, suggesting that "old" contamination could influence the sediment biocoenosis [3]. Ostracod mortalities at all sites are possibly due to elevated As concentrations at sediments. The mining and industrial activities could be contributing to the probable high levels of As in sediments at all three sites therefore the mortality and growth inhibition occurred at all studied sites. Ostracods have been found very sensitive to metal contamination than other freshwater crustaceans [3]. The comparison of the results of the biological assessment of three streams which were conducted on the basis of two different methods showed slight differences in the quality of streams. According to multimetric IO index all studied streams were classified as very good, good and moderate. This may suggest lower concentrations of As in water in relation to the sediments, which were not analysed during this study, but results obtained from Ostracodtoxkit F test indicate that the concentrations of this element in sediments could be elevated which has great impact to the development of living organisms such as crustaceans.

4 Conclusions

1. Assessment of the quality of three streams based on the multimetric IO index showed that studied streams qualify for three different water quality classes with very good, good and moderate ecological status. Stream Czysty Potok (0.72) was rated the highest, following by the stream Mąkolnica (0.6) and finally the stream Trujący Potok (0.36). This study has shown that diatom index responds well to environmental factors such as metal contamination.
2. All three streams were characterised by mortality and inhibition growth of ostracods exposed to sediments collected at studied sites. The lowest mortality and inhibition growth was observed in Czysty Potok, following by Mąkolnica and finally Trujący Potok which was in accordance with the calculations of IO and

chemical parameter (As concentrations). In this study, microbiotest applied, based on ostracods, proved useful in determining the potential toxicity of contaminated stream sediments.

3. Water pollution with arsenic affects significantly aquatic organisms and ecological status of the watercourses.

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References

1. T. Ciesielczuk, T. Olszowski, M. Prokop, A.A. Kłos, Ecol. Chem. Eng. S. **19**, 585 (2012)
2. T. Olszowski, B. Tomaszewska, K. Góralna-Włodarczyk, Atmos. Environ. **50**, 139 (2012)
3. Y.C. Cloete, B.F. Shaddock, A. Nel, Water SA **43**, 409 (2017)
4. X. Tan, Q. Zhang, M.A. Burford, F. Sheldon, S.E. Bunn, Front. Microbiol. **8**, 601 (2017)
5. J. Picińska-Fałtynowicz, J. Błachuta, *Przewodnik metodyczny. Zasady poboru i opracowania prób fitobentosu okrzemkowego z rzek i jezior* (GIOŚ, Wrocław, 2010)
6. B. Szulc, K. Szulc, Oceanol. Hydrobiol. Stud. **42**, 188 (2013)
7. A. Muszter, *Góry Złote-Geologia, okruszcowanie i ekologia* (Uniwersytet Wrocławski, Wrocław, 1995)
8. E. Rott, E. Pipp, P. Pfister, H. van Dam, K. Ortler, N. Binder, K. Pall, *Indikationslisten für Aufwuchsalgen in ÖsterreichischenFliessgewassern. Teil 2: Trophieindikation* (Bundesministerium fuer Land- und Forstwirtschaft, Wien, 1999)
9. E. Rott, G. Hofmann, K. Pall, P. Pfister, E. Pipp, *Indikationslisten fur Aufwuchsalgen. Teil 1: Saprobielle Indikation* (Bundesministerium fur Land- und Forstwirtschaft. Wien, 1997)
10. J. Schaumburg, U. Schmedtje, C.H. Schranz, B. Kopf, S. Schneider, P. Meilinger, G. Hofmann, A. Gutowski, J. Foerster, *Instruction Protokol for the ecological Assessment of Running Waters for Implementation of the EU Water Framework Directiv Macrophytes and Phytobenthos* (Bavarian Water Management Agency. Munchen, 2005)
11. OSTRACODTOXKIT F *Chronic "direct contact" toxicity test for freshwater sediments. Standard Operational Procedure* (Creasel, Dienze, Belgium, 2017)